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GEOLOGICAL AND BIOLOGICAL SCIENCES.

THE PHYSICAL FEATURES AND GEOLOGY

OF THE ROUTE OF THE

PROPOSED OTTAWA CANAL

BETWEEN THE

St. Lawrence River and Lake Huron

By R. W. ELLS, LL.D., and A. E. BARLOW, M.A.

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VII.—*The Physical Features and Geology of the Route of the Proposed Ottawa Canal between the St. Lawrence River and Lake Huron.*[1]

By R. W. ELLS, LL. D., and A. E. BARLOW, M. A.

(Read May 15, 1895.)

The construction of a direct water way between the upper great lakes and the head of ship navigation on the St. Lawrence, by way of the French, Mattawa and Ottawa rivers and Lake Nipissing, is a problem of by no means recent date. At different times the project has come prominently before the Canadian public, and the comparative shortness of this route, as compared with the distance traversed by the Welland and St. Lawrence system, has always caused it to be regarded with much favour by many who saw in its completion a probable diversion of much of the immense traffic of the West and Northwest from its present course, and a corresponding lessening of freight rates, which would go far towards solving the question of the successful development of our great western heritage.

The route of the proposed canal as indicated has, until quite recent times, formed one of the most important and convenient avenues for Canadian intercourse and commerce. For hundreds of years it was the favourite means of communication between the tribes of the East and the West. But in 1615 that intrepid explorer, Samuel Champlain, urged on by the spirit of adventure, and under the guidance of his friendly Algonquin allies, boldly ascended the Ottawa and pushed westward to the height of land at the source of the Mattawa. Here he crossed the divide, and, sailing over the beautiful waters of the great Lake Nipissing, descended the French River to its outlet on Lake Huron, and thus earned for himself the proud distinction of being the first man of European descent to gaze upon the broad expanse of our vast inland seas.

This route having thus been made known, other courageous voyageurs and traders, led on by a like thirst for adventure or by the hope of gain, speedily followed along the track Champlain had so bravely pointed out; and during the period of the French régime in Canada this constituted the principal highway of communication between the scattered colonies along the lower St. Lawrence and the vast and almost unknown areas now known as Western Ontario and the Northwest. For many years subsequently it formed the principal channel for carrying on the business of the Hudson's Bay Company, whose line of forts or trading

[1] Published by permission of the Director of the Geological Survey of Canada.

stations were distributed along its whole extent, at widely separated points. Along the waters of its several streams, and lake expansions also, the great brigades of boats and canoes passed year by year, bearing eastward the annual harvest of valuable furs and carrying westward, into the otherwise pathless wilds of our vast interior, the various kinds of merchandise which formed the staple of trade with the savages of the great western wilderness. Up to comparatively recent years, when through the advent of railway and steamboat communication, it has gradually fallen into disuse. it thus formed the main artery of traffic, the sheltered nature of its water stretches and the directness and shortness of the route recommending it at a time when the light birch canoe of the Indian trader formed the chief, and often the only, means of conveyance between the scattered hamlets of the sparsely settled country. These same potent reasons have likewise, in more recent years, been advanced by advocates of the projected through water-way who saw in this route the most feasible line for an improved direct canal system between the waters of the great lakes and the St. Lawrence. Acting under instructions, therefore, from the Commissioner of Public Works, Mr. Walter Shanly, C.E., in 1856-57,[1] made a detailed examination of the route contemplated, and pronounced most enthusiastically in favour of the scheme. In 1858-59[2] another examination was made by Mr. T. C. Clarke, C.E., in accordance with instructions from the Commissioner of Public Works, and he also reported in favour of the undertaking. The details of the surveys and estimates of the expense can be found fully stated in the reports of these engineers.

The discussion of the proposed canal route naturally falls under two heads, viz., that which pertains strictly to the engineering problems involved, and in which the public at large are more directly interested, and, secondly, that in which the great problems of Archæan geology are presented. For the consideration of the latter, probably no better section is anywhere presented; since it traverses the great development of the older crystallines, nearly at right angles to their strike, for several hundreds of miles. For nearly half a century the limestones and gneisses of the area along the Ottawa and the rivers west to Lake Huron have been studied by some of the ablest geologists both of Canada and of the United States, and the great variety of rocks here presented, including the

1 "Report of Walter Shanly, Esq., "On the Ottawa Survey," Toronto, March 22, 1858. Also, "Report on the Ottawa and French River Navigation Project," published by order of the Montreal Board of Trade, 1863.

2 "Return of the Recent Survey and Report of the Engineer on the Ottawa Ship Canal," Quebec, 1860, Thos. C. Clarke.

stratified gneissic and calcareous series, as well as the great variety of intrusives which are associated with these, furnish materials for the satisfactory solution of some of the most interesting and important questions in geological science. As for the engineering aspect of the question, it falls for the most part beyond the scope of this paper; but it is thought that a brief sketch of the principal physical features presented by the several rivers and lake expansions along the route proposed may be of general importance, since it presents, in a form readily available for reference, a mass of facts obtained not only from the earlier reports of the engineers who made the surveys but from careful personal examination as well. This, it is hoped, will render the discussion of the subject on any future occasion much more intelligible.

The total distance by the route proposed between Montreal and the waters of Lake Huron at the mouth of the French River is given by Mr. Clarke as only 430¾ miles, and this may, for convenience of description, be divided into two sections, viz., 1st, that along the Ottawa River itself from Montreal to the mouth of the Mattawa, a distance of 308 miles, and, 2nd, that along the Mattawa, Lake Nipissing and the French River, in all 122¾ miles.

Along the lower or Ottawa River section those portions of the system necessary to establish continuous communication between the cities of Montreal and Ottawa were completed nearly seventy years ago, and have ever since been regularly used in connection with the Ottawa and Kingston canal system. In this section is included the Lachine Canal, which was constructed to overcome the fall in the St. Lawrence above the city of Montreal known as the Lachine Rapids, in which the waters of the river have a descent of forty-four feet; 2nd, the Ste. Anne lock, near the junction of the Ottawa waters with those of the St. Lawrence, the fall here being only three feet, and the Carillon and Grenville canals, the improvements here extending over a distance of twelve miles and overcoming a total fall in the Ottawa River of fifty feet. The intermediate spaces, known as Lake St. Louis, Lake of the Two Mountains, and the long stretch of fifty-four miles between the head of the Grenville Canal and the foot of the Rideau Canal at Ottawa, have little or no current, and present no obstacles to navigation. The completion of these portions, therefore, has solved the practicability of the scheme for the first 116 miles of the distance.

No attempt has yet been made to overcome the interruption caused by the Chaudière Falls and the rapids above, where in a distance of six miles, the waters of the Ottawa have a total descent of sixty-seven feet;

but at the Chats Falls, which is the next obstruction at the head of the Lake Deschenes, twenty-eight miles further west, an attempt was made some years ago to overcome the barrier to continuous navigation there presented by the construction of a canal along the north bank of the stream. The total fall in the river at this place is fifty feet, the broken waters extending for quite three miles; but though a considerable amount of money was expended and excavations made along a considerable portion of the necessary distance, the project was never completed.

Passing the Chats Rapids, steamboat communication is continuous to the village of Portage du Fort at certain stages of water, the only difficulty at any time being presented by the small rapid known as the Chenaux, about four miles below that place, where there is a fall of from eight to ten inches only in the ordinary stage of water in the river. This stretch brings us to the foot of the chain of rapids and falls known as the Darges, the Mountain, the Sable, and the Grand Calumet, the whole extending for a distance of ten miles, in which there is a total descent of ninety-three feet, and bring us to the town of Bryson, on the north channel of the river past Calumet Island.

The river westward from Bryson presents no difficulties to steamboat navigation other than those caused by shifting sand-bars for about thirty miles, or to the foot of Allumette Island, which is at the upper end of Lake Coulonge. The shores of this portion of the river along the north channel of Calumet Island are generally low and composed of sand, with rock ledges at but few points; but the south or Roche Fendue channel is much more broken, heavy rapids and pitches occurring for some miles or to within about three miles of the head of the island. At the foot of Allumette Island two channels of the Ottawa unite. On the south channel the navigation is obstructed by two rapids, the Paquette and the Allumette, the former at the lower end of Allumette Island near the junction with the north channel, and the latter about three miles below the town of Pembroke. These present a well-defined barrier to the navigation of this channel, though the fall in either of the rapids is not of great amount; while in the north channel the obstructions caused by L'Islet and Culbute rapid and fall are overcome by a lock, constructed about twenty years ago, by which a total descent in the river of eighteen feet is overcome. By this means continuous steamboat communication is secured from Bryson to the foot of the Des Joachims Rapids, a distance in all of seventy-seven miles, and steamers ply regularly between the town of Pembroke and the latter point. The portion of the Ottawa for thirty

miles below the Des Joachims Rapids is known as the Deep River, the stream flowing in a nearly straight course between generally lofty hills of reddish syenite and granitic gneiss. The water along this portion is generally very deep, and the river presents magnificent stretches of the grand scenery found in the Laurentian hills, resembling in this respect to a great extent the gorge-like aspect of the Saguenay.

From the Des Joachims to the forks of the Mattawa the distance is only fifty-two miles, and in this stretch the navigation is broken by the Joachim itself, with a fall of twenty-eight feet in two miles, above which the course is clear for sixteen miles to RocherCapitaine rapid and fall, one of the finest in the river, the descent here being forty-five feet and the obstruction extending for two miles. In the stretch between these two rapids the waters of the stream have a fall of eight feet, in which is included McSorley's Rapid, with a fall of almost three feet, sufficient to impart a perceptible current, but otherwise offering no hindrance to continuous navigation. Ten miles above the Capitaine the three rapids known as the Trou, the Deux Rivières and L'Eveillè occur, extending for three miles, with a total descent of thirty-two feet. Between this and the junction with the Mattawa River three obstructions occur, viz., the Rocky Farm Rapid, with a rise of eight feet in five miles; Johnson's Rapid, with a rise of four feet in half a mile, and the Mattawa Rapids, with a rise of three feet, the latter just below the confluence of the Mattawa and Ottawa.

The Mattawa River though perhaps not the largest tributary of the Ottawa is nevertheless the most important and widely known. It may perhaps be best described as a succession of large deep lakes, united by comparatively narrow and shallow rocky streams. The total length from its junction with the Ottawa to the western end of Trout Lake which forms its head waters, in a straight line is about thirty-six miles, while following the course of the river this distance is increased to forty miles. The course is in general nearly east and west, following very much the same valley occupied by the Ottawa below the confluence of the two streams. At the junction, the Ottawa which above this has pursued an almost due southerly course turns abruptly to one not many degrees south of east, which course is maintained for a considerable distance below this point. The streams come together at the elbow thus formed, the Mattawa curving sharply northward at its immediate junction with the main stream. The mouth of the Mattawa comes out on a low flat point composed of sand, gravel and boulders. The southern bank of the river projects in a long narrow point which at low water stretches

almost completely across the Ottawa leaving only a narrow though deep channel close to the base of the almost perpendicular cliffs of the northeastern shore. The position of this bar and the size and character of the material composing it, as well as its resemblance to other ridges of boulders which cross the Ottawa in many places throughout its course, would seem to indicate rather clearly its "morainic" origin. This obstruction causes a considerable rapid which, with an accompanying swift current below, gives a fall of about five feet. The loose material causing the rapid next mentioned has doubtless been considerably modified, since its deposition, by alluvial action; and a rather well defined channel, which must formerly have served as an outlet for the water coming down from the west, runs through the flat point on which the village of Mattawa is built, reaching the Ottawa at the foot of the rapid just mentioned and about a mile below its present mouth.

Ascending the Mattawa, rapid water is encountered almost at once, the stream here flowing over a shallow bouldery bed. This, together with a small rapid a little over a mile above at the outlet of Boom Lake, gives a fall in the river of about two feet.

Boom Lake, the first expansion reached, is only about a mile and a quarter long, and not over a quarter of a mile at its greatest width. At the upper or western end of this lake, the river is contracted in two places to a width of less than a hundred feet, and a fall of nearly twenty feet is occasioned by the Plein-Chant Rapids. The fall is in two descents with an intervening stretch of quiet water, the larger one near Boom Lake alone having to be "portaged." Lake Plein-Chant, at the head of these rapids, is a beautiful stretch of deep water, five and a half miles in length. The widest portion is near the eastern end, where it is about thirty chains, but this gradually diminishes westward till near the upper end it is not more than three or four chains wide. In the wider portion the sounding lead indicated a depth of over two hundred and eighty feet. Between this lake and Lac des Aiguilles, as the next expansion is called, the distance is a little over two miles and four rapids intervene with alternating stretches of still water, the combined fall of which is eighteen feet. The three largest rapids are known in ascending order as "Les Epines," "La Rose" and "des Rochers" or "des Aiguilles." The Amable du Fond River, the largest tributary of the Mattawa, enters from the south side a short distance above the second rapid. We next come to Lac des Aiguilles which is a little over a mile long and a quarter of a mile wide. It is separated from the next succeeding stretch of river lying parallel to it on the

north side, by a rocky bar known as "Les Aiguilles" Islands. The three narrow rocky channels formed by these two islands even at high water barely afford a passage to loaded canoes. The eastern one constitutes the main connection, and a small rapid at this point shows a descent of a few inches. Above this we enter a long stretch of deep water which gradually diminishes in width as we ascend. The river throughout this distance of two and a half miles is flanked on either side by almost perpendicular walls of gneissoid granite, which in the narrower places especially, give it the aspect of a beautiful natural canal. At the end of this stretch, the upward course of the river changes sharply to a southerly direction for about two miles, and the progress of navigation is obstructed by a series of rapids, with intervals of deep water, the total fall in this distance being fifty-five feet. The Chute des Paresseux, where the water of the river is precipitated in a beautiful fall thirty-four feet in height, is the first and greatest of this series of interruptions encountered in the ascent of the stream. Pimisi or Eel Lake, above these rapids, marks another change in the course of the stream, and from this place to the head of Talon Lake it maintains a northwesterly direction. Between Pimisi Lake and the Talon Chute the river flows for three-quarters of a mile through a narrow rocky canon inclosed between perpendicular walls of granite. At the Talon Chute, which is the greatest single fall on the whole river, the water is precipitated a distance of forty-three feet over a rocky ledge composed of massive flesh-red gneissoid granite. The main channel is on the north side, but, in addition, there is another though much smaller passage parallel to this, which, at high water, affords an exit to a considerable quantity of the water of the lake. The downward extension of this passage is continued in a deep gorge, which connects with the main channel a short distance below the falls, the whole apparently representing the erosion of a band of crystalline limestone or ophicalcite which here occurs associated with the granite. About half a mile above Talon Chute a small rapid occurs with a descent of less than a foot, and, a short distance westward, Talon Lake opens up to view. To the left, as we enter the lake, a large bay extends westward about three miles, known as Kabiskaw Bay, at the western extremity of which an important tributary (Kabiskaw Creek) enters, forming the outlet of Nasbonsing Lake, a large and irregular sheet of water situated in the southern part of the township of Ferris.

Lake Talon has a trend of northwest and southeast, is about seven miles long and has, in general, a breadth of almost three-quarters of a mile. The shores are frequently bold and rocky, although occasional

small sandy flats occur, and one of these, known as Graswell's Point, on the northeast side about half-way up the lake, has always been a favourite camping spot. Shield's Point, near the lower end of the lake on the southwest side, is a tolerably level flat, composed chiefly of sand, gravel and other loose material. This point juts out into the lake, forming a bar where the water appears to be much shallower than in the rest of the lake. The general depth may be said to vary from fifty to one hundred feet, but in occasional spots a depth of two hundred feet and over was met with. The connecting stream between Talon and Turtle or Lower Trout Lake, as the next expansion in the river has been called, is about four miles. The stream leaves Turtle Lake about a mile from the eastern extremity. It is a shallow river often rocky and rapid with some small intervening ponds of deep water. The upper part flows through a rocky defile, while the remaining half pursues a serpentine course through a sandy alluvial flat. On leaving the lake the stream assumes a northerly direction, but gradually curves around to the northeast, entering Talon Lake at the northwest end. This formerly constituted a part of the regular canoe route but is now seldom used, and scarcely a trace remains of what must at one time have been a well-beaten portage trail. The route now adopted leaves the eastern extremity of Turtle Lake over the "Portage de la Mauvaise Musique" to Lac des Pins, and thence, by a portage a little over half a mile in length, into a bay of Talon Lake about a mile below its upper end.

Turtle or Lower Trout Lake as it is sometimes called, runs nearly east and west, and is about four and a half miles in length, although not more than half a mile at its widest place. An ascent of barely a foot occurs in a short channel, cut through boulders and other loose material, before the largest lake and the summit level of the river is reached. Trout Lake is a magnificent expanse of pure clear water often over two hundred feet in depth. The shores, especially those to the north, are bold and rocky, and towards the western end many beautiful rocky islands dot its surface. It is eight and a half miles in length and the greatest bredth near the upper end is about two miles. At this place, however, the lake is divided into two portions by a bold rocky peninsula about four miles long, extending in an east and west direction, so that a large part of the lake is thus concealed from view. Towards the eastern end, the lake gradually tapers till the outlet is reached. To the north a range of hills, from three hundred to four hundred feet high, runs with unbroken continuity to the mouth of the Mattawa River. The extreme west end of Trout Lake is only about three miles distant from the

eastern shores of Lake Nipissing, and the neck of land separating the two lakes is in general very level, though bouldery, with numerous small lakes and ponds which apparently have the same elevation as Trout Lake, and which empty their waters into Lake Nipissing through Otchipwé Creek, and one or two other small creeks. Indeed, it is reported that a line can be chosen with one of the branches of Otchipwé Creek which would show a summit level of less than three feet above the waters of Trout Lake. The canoe route usually followed, however, leaves the lake in a bay running to the south near the western end of the lake. The first portage runs over a ridge of sand, through which the solid rock may be seen protruding, about twenty-five feet above Trout Lake. The Rivière de la Vase is then utilized all the way to Lake Nipissing, a distance of a little over six and a half miles. This river or rather creek, for it is very small, runs through low and often marshy ground the most of the way, entering Lake Nipissing about six miles southeast of North Bay. Two alternative routes have been proposed for the canal through this isthmus, viz., 1st, that by way of the valley of Rivière de la Vase, and 2nd, that by way of the Otchipwè Creek. The latter route seems to have a decided advantage both in regard to distance and cost, as it is only about four miles by this line. The canal would also have its entrance on a fine deep and unobstructed bay on Trout Lake, while it would reach Lake Nipissing in the immediate vicinity of North Bay, the most important town in the district. The land in the immediate neighboorhood of the Mattawa River, with few exceptions, is rocky and barren, and generally unfit for agricultural purposes. At the mouth of the Mattawa, and at several places immediately adjoining Lake Talon, a few isolated areas are under cultivation. A short distance from the river, however, in the townships of Papineau, Calvin, Bonfield and Ferris, considerable areas have been cleared, and good progress has already been made in the settlement of these townships. The townships to the north of the river are still uncleared, with the exception of portions of Widdifield, to the northwest of Trout Lake, where a considerable number of farmers have started to make homes for themselves. The country rises rapidly to the north of the Mattawa River, the latter occupying a deep valley similar in character to that which contains the Ottawa, and the high steep hills which border both streams represent the edge of a large and comparatively level plateau, from three hundred to four hundred feet above the general level of the water of both streams. There seems to be no doubt that good sized tracts exist to the north of the Mattawa, which are well suited for farming purposes, but at present they are too inaccessible to be of much value.

Lake Nipissing is a large and important sheet of water having in general an east and west direction. The greatest length from the shore at East Bay, near Callender station, on the northern division of the Grand Trunk Railway, to the western end of Bear Bay (West Arm) is sixty miles, while the greatest width from Beaucage Bay on the north to the mouth of the South River is sixteen miles. The northern and eastern shores of the lake are in general low, and, for the most part, present beautifully curving beaches of yellow sand separated by low rounded points of rock. The water for a considerable distance from the shore is shallow, and its approach is thus rendered more or less difficult and dangerous, especially during stormy weather. The western end of the lake possesses a most irregularly indented coastline; and many large arms or bays extend for miles to the westward filled with rocky islands. A great number of these islands stud the surface of the more open water outside, running in long lines more or less parallel, and usually in continuation of the peninsulas or points which divide the bays from one another. The islands vary in size from the small rounded rock, destitute of vegetation and often only exposed at low water, to some which are several miles in extent. The southern shores are bold and rocky, and the water very deep, even in their immediate vicinity. Occasional small coves between these rocks exhibit beaches of yellow sand or fine gravel. The whole of the eastern end of the lake is wide and exposed, containing only two small groups of islands, called respectively the "Manitou" and "Goose" Islands. The route from the mouths of either the Rivière de la Vase or Otchipwé Creek passes in the vicinity of the first-named group, the distance across to the mouth of the Southwest Arm, out of which the French River flows, is eighteen miles, which is unobstructed by rock or shoal of any kind. This Southwest Arm is about twelve miles in length and from one to two miles wide. It is filled with numerous islands and large and intricate bays extend to the west and northwest. From the most southerly of these bays the water finds its way into the lake-like expansion of the main river, about two miles northeast of the "Rapide du Pin."

The French River from the head of the Chaudière Falls, which mark the first obstruction in navigation to its mouth on Lake Huron, is forty-eight miles in length. It may best be described as a series of very long and comparatively narrow, though deep, lakes separated by rocky dams or bars, which impede the course of the water, thus giving rise to the various falls and rapids. The water escapes by numerous rocky channels which bear a marked resemblance to one another The presence

of many of these was unsuspected, until the detailed survey made of the river by Mr. Alexander Murray of the Geological Survey in 1856. The two longest channels are known as the "North" and "South," and each of these is divided into an east and west portion. The old travelled canoe route utilized the "South Channel East" in the upper portion of the river and the "North Channel West" in the lower portion as they are nearly in line with one another and form the best and most direct course. This is the channel proposed to be followed by the canal, and it seems admirably adapted for the purpose as the natural obstructions present no great engineering difficulties. The presence of two or more channels would also materially aid in the prosecution of any improvement, as by damming an outlet the water below the dam would assume a lower level and thus enable work to be carried on to greater advantage.

The country in the vicinity of the French River is in general rocky and barren, presenting numerous more or less rocky hills or ridges, which are in no case of any great height, with intervening stretches of comparatively level land, which are usually occupied by swamps. There are occasional small tracts of good land, chiefly to the north of the river but the shores are, as a general rule, bold and rocky. The Chaudière Falls are divided into two descents, separated by an interval of still water, the total fall being about twenty-six feet, and the whole length about a mile. At the Lower Chaudière the perpendicular rocky banks of the river are not more than fifty feet apart Between the Chaudière Falls and the next interruption in the stream, "Rapide du Pin," the river widens into a lake about eight miles long, containing numerous islands. In general this stretch of water is from half a mile to a mile in width, although at one place opposite Bear Point it is scarcely a quarter of a mile wide. The outlet of the north channel, which, after a course of twenty-three miles, empties into the main channel about two and a half miles above "Grand Recollet Falls," is at the west end of a small bay extending to the northwest from above "Rapide du Pin." This rapid has a fall of 2.60 feet, and in the next four miles the stream is interrupted by as many rapids, which are known as "La Grande Faucille," fall 5.60 feet; "Rapide du Buisson," fall 3.30: "La Petite Faucille," fall 4.40 feet, and "Le Parisien," fall 1.20 feet. A stretch of deep still water then ensues which is seventeen miles in length before the falls of "Le Grand Recollet" are reached. These are occasioned by a rocky bar which here extends across the river. In the next sixteen miles, before "Les Petites Dalles" are reached, as the last rapid on the river is called, there are only two small rapids. The first, about a mile below "Le Grand Recollet," shows a descent of scarcely a foot; while the second one,

about four miles further down, has a fall of only two feet. Eleven and a half miles below "Le Grand Recollet" Falls the river, which has heretofore had a direction a little south of west, changes abruptly to the south, which course is maintained for three miles further, when the route again changes to the west for one and a half miles, at which point the rapids known as "Les Petites Dalles" show a descent of six feet to the waters of Lake Huron. This brings us into a narrow inlet about two and a half miles in length, extending northward from Georgian Bay, and constituting the most westerly of the middle outlets of French River. The waters of French River empty into the northern end of Georgian Bay through a series of channels forming a curiously complicated rocky delta It has been customary to designate these mouths as the "western," "middle" and "eastern" outlets. The western outlets are four in number, three of which empty into the eastern end of the inlet marked on the last chart (Commander Boulton, 1886) "Voyageur Channel," while the fourth, known as the "Mauvaise" or "Bad" River, reaches the lake nearly two miles east of this point. These channels unite in their upward course in a narrow lake about three miles from Georgian Bay, and continue together in a north-easterly direction for four miles, when the course suddenly changes to the east. The middle one of these three channels is the one pursued by canoes coming from the west, while canoes coming from the south, along the shores of Georgian Bay, generally found their way into French River by way of Henvey Inlet or "The Key," from both of which bays there is an easy portage, routes coming out on the south channel of the French River opposite Cantin's Island. The eastern and middle outlets were therefore seldom used, and it is accordingly not surprising that so little was known with regard to them. The middle outlet consists of two rocky channels, which enter the lake within two miles of one another immediately north of the Bustard Islands. The eastern outlet consists of but one channel, which comes out in a bay about twelve miles east of the most western outlet. The middle and western outlets run in a north or north-easterly direction for five or six miles, when they intersect the lake-like expansion of the river known as "Lac le Bœuf," while the easterly outlet empties that portion of the river known as the "South Channel West," nearly two miles above its junction with the western part of the north channel. Before a decision could be arrived at in regard to the feasibility of this route for purposes of canalization, it was necessary that a detailed examination should be made to determine whether a suitable harbor could be found near the terminus on Lake Huron. Previous to 1856 the prevailing opinion

was that such could not be found, and that the mouths of the French River were so beset by islands and rocky shoals that they could not be approached with any degree of safety by any craft larger than the ordinary bark canoe. An examination of the chart of Georgian Bay (surveyed by Capt. H W. Bayfield, 1822) seemed to strengthen these views; for while this plan revealed the western outlets of the river, coming out in a perfect labyrinth of bays, islands and rocky shoals, no notice whatever is taken of the eastern outlet, and the middle outlet was simply noticed as affording an exit for the water of a "large river." The detailed and accurate survey of Mr. Alexander Murray, in 1856, for the Geological Survey of Canada, and the later detailed and special examination of Messrs. Clarke and Shanley, revealed the fact that the most westerly of the middle outlets of the French River was excellently adapted for the purposes of a terminal harbor. In 1875 Mr. Ridout made a careful survey of this outlet in connection with his work of exploration for the route of the Canadian Pacific Railway. The soundings then taken showed a straight channel not less than a quarter of a mile wide and thirty feet deep from the lake into the bay into which this outlet empties. In 1879 Mr. E. P. Bender made a detailed examination of the French River with regard to its practicability for canal purposes, in connection with certain explorations for the Canadian Pacific Railway Company, and, as an indication of the sheltered position of this harbour, mentions the fact that many of the pickets planted near the water's edge by Mr. Ridout were still standing at the time of his visit. At the instance of the Marine and Fisheries Department, four lighthouses have been erected. Two of these are situated in line on the Bustard Rocks, to the west of the Bustard group of islands. Another has been built on Lefroy Island near the western entrance of the bay; while the fourth is situated on the eastern shore of the harbour itself, about a mile further north. The channel, though somewhat narrow, is straight and deep, and, with the lighthouses now in position, ought to be accessible to any of the vessels afloat on the Great Lakes.

The country traversed by the Ottawa is more diversified than that along the second or Mattawa and French River section. For while the Laurentian Rocks may be said to form the chief geological feature of the area, the hills at various portions recede from the river, and the valley of the Ottawa itself is at times occupied with the recent sediments, which sometimes extend for several miles on either side. This feature is more particularly seen along that part of the valley between the Chats Falls and the city of Montreal,

the country on either hand often being nearly level or broken by low rolling hills, and occupied by flat lying beds of the Potsdam, Calciferous, Chazy and Trenton formations which rest unconformably upon the upturned edges of the Laurentian gneiss and limestone At two points only in this distance do the Archæan rocks cross the river, viz. at Rockland, twenty-five miles below Ottawa, and at Montebello, about twenty-five miles further east, where the characteristic crystalline rocks of the Laurentian show on the south bank of the river and are directly overlaid by the Potsdam sandstone. The banks of the river generally, along this part of the section between Ottawa and Montreal, are low and composed of marine clays. The long range of the Laurentian hills, intersected by the deep valleys of the Rouge, the Nation, the Lièvre and the Gatineau Rivers, which are tributary from the north, rise in graceful contours in places, to elevations of 800 to 1,000 feet above the waters of the river; while to the south, the country is so generally level, that the South Nation River which joins the Ottawa, forty miles below Ottawa City, takes its rise within little more than a mile of the St. Lawrence, in the vicinity of Brockville. The soil in this area is for the most part excellent, though several extensive deposits of peat occur, destined probably at no very distant day to be of considerable economic value. Above the city of Ottawa to the Chats the nearly horizontal beds of the Calciferous and Chazy formations are well exposed, especially along the south shore, and in places contain extensive beds of limestone, excellently suited for building purposes. The rapids and falls of the Chaudière, at Ottawa itself, are caused by the heavy ledges of Trenton limestone which here cross the river, and on which the city of Hull on the north, and to a certain extent, Ottawa, on the south bank, are built.

Above the Chats Falls and rapids, which are produced by a rocky barrier of crystalline limestone intersected by several heavy dykes of syenite rock, the principal of which is seen to cause the Fall itself, the areas of these sedimentary rocks are quite limited till we reach the head of the Calumet Island Channel. Beyond this, however, to the head of the Allumette Island, and on the south side of the river adjacent, the beds of Chazy and lower Trenton have a very considerable development. Hills of granitic and syenitic gneiss rise on the north, almost from the shore of the river, while broad stretches of sand occur which overlie the marine clays of the district. From Pembroke west to the Mattawa these sands are widespread, and occupy extensive areas, through which isolated masses of the syenitic and granitic rock protrude. Upon these latter also at widely separated intervals, out-

liers of fossiliferous Silurian strata are found, which have escaped the great denudation which affected the whole of this area.

It would appear from the presence of these sedimentary formations along the present channel of the Ottawa, that the valley itself must have been formed at a very early date, and in fact that it constituted a chief outlet for the drainage of the portions of the continent from early Archæan times.

Along the projected route of the canal system the summit level is found near the western end of the section at Trout Lake, 348 miles west of Montreal, or 82 miles east of the western terminus at the outlet of the French River, in Georgian Bay, and the elevation here is 667 feet above sea level, that of the surface of Lake Huron being 581·3 feet; while the low water level of the River Ottawa, at the junction with the Mattawa, 308 miles west of Montreal, is 498.9 feet. The elevations for the various stations along the entire route will be found in an appendix, in which the figures, as given in the reports of the canal engineers, have been carefully corrected by Mr. James White, chief cartographer of the Geological Survey Department, in accordance with the most recent hydrographic surveys.

Indications of changes of level in past times are readily observed at many points along the course of the Ottawa River in the presence of terraces, drift sands and clays and old river channels, which have since been closed through the accumulation of drift material, as sands and gravels, and the waters again diverted to their original course. Among these old water courses one may be noted at the Des Joachims Rapid to the north of the present river channel, which it reached by way of McConnell Lake and stream through the depression north of the village of Des Joachims itself. Another evidently turned off from the Deep River about fifteen miles below the Des Joachims Rapids, and extended by way of the Sturgeon Lake and Bay, into which the waters of the Chalk River now empty, thus cutting off the bold headland known as the Oiseau Rock on the Deep River and the high point at the sharp bend of the river below called High View. The banks of the Ottawa below the outlet of this old channel are composed of great masses of reddish sand, forming banks from twenty to sixty feet in height, which extend along the course of the stream for some miles. A second former channel evidently extended from the town of Pembroke, by way of the Muskrat River and Lake, from which the course can be traced by a series of depressions, dotted by a chain of lakes to the present channel on Chats Lake, near the Chenaux Rapids, several miles above the mouth of the Bonnechere. Opposite the city of Ottawa also another channel is seen

in rear of the city of Hull; while it is probable that still another channel passed to the south of the city of Ottawa by way of the Hintonburg depression and Dow's Swamp into the present channel of the Rideau.

The deposits of sand and clay on the lower Ottawa are in places of great thickness, and show that the denudation of the old channel must have been very heavy. Between the Laurentian range at Lachute and the Lake of Two Mountains bore-holes have been sunk to a depth of 120 feet without reaching the underlying rock, while terraces of drift rise to the north of the boring to a height of from fifty to sixty feet, thus showing that the drift deposits must be not far from 200 feet in thickness at this place. The exposures of marine clay with characteristic fossils, found on Lake Coulonge, more than 200 miles west of Montreal, at elevations of 360 feet above the sea level, show that the waters of the ocean extended for a long distance inland during the period of depression.

The sedimentary Palæozoic formations found along the Ottawa river and in its vicinity include all from the Potsdam to the Lorraine shales which mark the summit of the Cambro-Silurian system. The greater part are well characterized by the fossils peculiar to each formation, and the stratigraphical sequence can be well observed at various places. There does not appear to be any defined break throughout the whole series, though the estimate of their total thickness is affected to some extent by the presence of local faults. The basal beds of the lowest or Potsdam sandstone are in places made up of the débris from the Laurentian gneiss and limestone, while in other places the sandstones are penetrated by dykes of granite, which were formerly considered as integral portions of the Archæan rocks. The descriptions of these various divisions of sedimentary rocks are given fully in the earlier reports of the Geological Survey of Canada, and need not be here repeated.[1]

At several places along the Mattawa and Lake Nipissing portions of the route certain Palæozoic strata are also seen resting in almost horizontal beds on the hummocky surface of the pre-existing Archæan. A few of these outliers may be noticed at low water dipping from the edge of the gneiss, and forming a portion of the bed of the Ottawa River a few miles below Mattawa. The rock is a light gray arenaceous limestone, and the study of the few fossil remains which were obtained points to their being of Black River age. Strata representing the same period,

1 Geological Survey Report, 1845, W. E. Logan; 1851, A. Murray.

and containing much more numerous and better preserved fossil remains, were also noticed on several of the Manitou Islands, in Lake Nipissing. The thickest section of these rocks appears to be near the southwest end of McDonald Island, the second in size of the Manitou group, where these rocks have a thickness of about thirty feet. The lowest bed exposed on these islands appears to be a coarse arkose made up of angular or subangular fragments of the subjacent gneiss, cemented together by a coarse sandstone or grit. This has no great thickness, and graduates quickly upward into a sandstone holding corals and fragments of what must have been in some cases very large orthoceratites. This in turn gives place to a gray limestone, which continues to the top of the series. Near the southwest end of Iron Island beds of a coarse sandstone or grit rest unconformably upon the gneiss, dipping at a very low angle to the west.

The Archæan rocks which form the great bulk of the strata thoughout the entire area under consideration have been studied by various observers for three-quarters of a century, As early as 1821 Bigsby described the rocks north of Lake Huron as granite, gneiss, trap, etc., all of which were at that time assigned to the primitive formation. In 1827 the same observer also described similar rocks along the north side of the St. Lawrence in the vicinity of Quebec. Among subsequent early writers on these rocks were Sir Wm. Logan, Murray, Bayfield, Emmons and Hunt, while in more recent years Macfarlane, Selwyn, Vennor, Bell, Barlow, Lawson, and others have added many important facts relating to their distribution, origin and general structure. The terms Laurentian and Huronian, given by Logan and Murray in 1852-54 for the two great divisions of the Archæan, have ever since been generally adopted by workers in this portion of the geological field.

A description of the crystalline rocks along the Ottawa River section and of the country adjacent was given by Sir Wm. Logan in his report for 1847. At that time they were regarded as, for the most part of metamorphic origin, the supposition being that they were orginally deposited like the sediments of later Palæozoic times. The principal rock mass was stated to be a red syenitic gneiss, with hornblende and mica arranged in a parallel direction. On the Madawaska River, a branch of the Ottawa in the south, a section of 1,350 feet was measured which comprised gneiss, crystalline limestone and micaceous quartz rock, in which the calcareous members were in three bands and interstratified with the gneiss. The whole series at this point presented many of the physical features of altered sedimentary strata, and they were supposed to conformably overlie the great area of syenitic rocks

more especially developed to the west. Both series were intersected by clearly intrusive granitic and pyroxenic dykes and veins.

In 1852 the series of crystallines north of the Ottawa and St. Lawrence was examined, and in 1857 the report of Logan on the areas west of Montreal was published. These rocks, consisting of gneiss, limestone, quartzite and anorthosite, were all styled metamorphic sediments, following the principles enunciated in the earlier report on the area to the west. The presence of eruptives, such as syenite, porphyry, diorite and trappean rocks of various kinds, was noted, but all these were regarded as older than the Potsdam sandstone, which at various points was observed to flank the base of the Laurentian hills. In this series also the anorthosites were considered as being an associated division of the limestones, and as possibly belonging, with them, to one great undulating mass. It was not, however, till the publication of the Geology of Canada, 1863, that anorthosites or Labradorite rocks were stated to form the upper member of the Laurentian series, being there said to probably constitute an upper unconformable division to the crystalline limestone, with an approximate thickness of 10,000 feet. This area of rocks north of the lower Ottawa was styled the Grenville series,[1] and was regarded as representing most completely the structure of the oldest crystallines of Canada.

In the meantime Logan's co-worker, Murray,[2] described the usual series of gneisses, crystalline limestone and quartzite of the Thousand Islands and of the mainland to the north, with associated areas of what he regarded as conglomerates, the latter being held to be conclusive evidence of the sedimentary and metamorphic character of the whole. In 1853[3] he made a traverse from Lake Huron by way of the Muskoka and Petawawa rivers to the Ottawa, a route approximately parallel to that by the Mattawa and Ottawa, and in the ensuing year,[4] he made further explorations in this area by a traverse towards Lake Nipissing along the Meganatawan River. In 1855 he completed the examination of this section by the exploration of the Nipissing and French River route.[5] In his descriptions of the several sections then examined Murray enumerates the usual variety of red and gray gneiss, micaceous and hornblendic schist, quartzite and crystalline limestone, as well as

1 Geological Survey Report, W. E. Logan, 1853-56.
2 Geological Survey Report, A. Murray, 1851-52.
3 *Ibid.*, 1853-56.
4 Geological Survey Report, A. Murray, 1853-56.
5 *Ibid.*, 1853-56.

certain areas of reddish syenitic rock, in which the stratification was entirely absent or very indistinct, which were regarded as probably intrusive; while the country rock generally was held to be metamorphic. The whole series was found to be everywhere corrugated, often with steep bends and folds, and intersected by quartzo-felspathic dykes and quartz veins.

The gradual evolution of the problem of the composition, origin and structure of these oldest Laurentian rocks which were so extensively studied by Logan, Murray and Hunt prior to 1863, required much careful study, both in the field and laboratory. The difficulty of arriving at satisfactory conclusions in the field at that early date can be scarcely appreciated at the present day; since forty years ago much of the area covered by the Laurentian rocks was accessible only with great trouble and expense, while the men skilled in the interpretation of such a complicated geological structure as was thus presented were few. The problem undertaken by these pioneers in Canadian geology was not only new but one of exceeding difficulty, yet the results then arrived at, with the limited means at their disposal, have been accepted as conclusive by most workers in this field for many years. The more recent field work of Lawson[1] on these rocks as developed to the west of Lake Superior about the Lake of the Woods and elsewhere, and by Bell[2] in the country north of Lake Huron, gradually led to the conviction, on their part, that much of what had been regarded as the oldest member of the Laurentian, viz., the syenitic gneiss, destitute of limestone, was of more recent age than the stratified gneiss and limestone series with which they were associated; and that, in fact, these had been intruded into the gneiss at a date subsequent to their deposition.

An examination by Dr. F. D. Adams in 1885-86, of the great anorthosite areas of Morin and the townships adjacent, which had been regarded as the upper part of the Grenville sedimentary series, led him also to the conclusion that these could no longer be regarded as altered sediments but that the anorthosite was clearly intrusive through the Laurentian limestone and associated stratified gneiss, and consequently of more recent date. These examinations extended over several years and embraced large areas both to the north of Montreal and in the Quebec and Lake St.

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1 Geological Survey Report, vol. iii., new series (F), A. C. Lawson, 1887-88, On the Rainy Lake region."

2 American Geologist, vol. vi., pp. 19-32 (July, 1890); Bulletin G. S. A., vol. iv., pp. 313-332.

John district, and the results arrived at by Dr. Adams as to their eruptive character, based upon an exhaustive study, both in the field and by the aid of the microscope, must be taken as conclusive on this subject.[1] Thus the study of the Laurentians both on the extreme east and west of the typical area has strongly tended to establish the opinion that many of the usually accepted views as to the structure and origin of the syenitic and granitic gneiss and of other portions of the great Archæan complex require to be very considerably modified.

In the consideration of a question of such great extent and of such complexity as that of the origin and structure of these ancient crystallines presenting as they do such variety in composition and physical character, with such diversity of relations, it is to be feared that much of the apparent discrepancy of opinion has arisen from the attempt to solve the problem by a study of too limited an area, or from a too rapid generalization from insufficient data, too often obtained from unreliable sources. The methods of study of the older crystallines and eruptives also have materially changed during the last twenty years; and the revelations of the microscope have thrown much light upon questions which for a long time were perplexing in the extreme. Thus it has gradually come about that much of what, in the early days of the study of this series of rocks, was considered from their physical characters, chiefly of aqueous origin, has been clearly shown to have originated in an entirely different manner, and that many of these rocks, formerly supposed to be sedimentary, are, in fact, truly igneous masses. While many differing views have been expressed by the several workers in this very interesting geological field, it may be stated that the Grenville series or the original typical Laurentian area of Logan probably most fully illustrates the most perfect section of the Laurentian rocks which we can yet recognize. This section embraces a great variety of rock structure. It includes the various kinds of gneiss, foliated and stratified, with foliated and massive granites and syenites, pyroxenic and dioritic, hornblende and quartzose rocks, quartzite and limestone. In the basal beds of the latter are interstratified bands of rusty quartzose gneiss which, from the evidence yet at our disposal, form an integral part of the calcareous formation. This portion presents in its banded arrangement of quartzose and calcareous rocks, the usual aspect of true altered sedimentary strata. The same well banded arrangement is also visible in some

[1] "Ueber das Norian oder Ober-Laurentian von Canada" aus dem Neues Yahrbach für Minerologie, etc., Beilageband, VIII., Stuttgart, 1893.

of the directly underlying gneiss; but in the case of the great mass of this gneiss, the microscopic examination shows the evidence of an aqueous origin to be wanting. Whatever may have been their origin however, the alteration into the gneissic and crystalline condition must have been completed prior to the deposition of the sedimentary Cambrian or other rocks which now rest upon them, since in the case of the Potsdam formation, and, in fact, of many of the beds of the lower Cambrian, there is but small indication of a gneissic or crystalline structure, except where this has been produced directly through local causes. That there has been a subsequent crystallization or metamorphism, even in the crystalline limestone of the Laurentian, is clearly evidenced by the presence of intrusive masses of diorite, syenite or granite which have developed crystals of mica, graphite and other minerals along the line of contact. Through the same cause also the limestone itself in places is changed to an ophicalcite by the formation of grains of serpentine through the crystalline mass.

While it is now clearly established that some portions of the igneous rocks of the Laurentian area, as developed in the area along the Ottawa are of more recent age than the crystalline limestones which are supposed to constitute the upper member of the series, certain other portions are undoubtedly older, and these most probably represent the lowest portion of the earth's crust known to us. These oldest gneisses are foliated rather than stratified; but in their foliation they underlie the regular series of stratified hornblende and other gneisses which occur frequently between the fundamental gneiss and the crystalline limestone and quartzite series at the summit of the sections. To this fundamental series may be assigned the rocks of the Trembling Mountain which were assumed by Logan to constitute the lowest member. Similar rocks occur as anticlinals north of Lachute, and at different places throughout the Grenville district, while large areas occur at various points along the upper Ottawa River section. Concerning much of the intermediate gneisses, it may be said that while in their general aspect they resemble stratified sedimentary rocks, their study under the microscope shows them to have presumably a different origin, so that it is possible that the true altered aqueous portion may be confined to the areas of crystalline limestone with their associated bands of quartzite and grayish quartzose and hornblende gneiss. But concerning this latter series it must also be said that a considerable diversity of opinion already exists, some regarding the sedimentary origin of these rocks even to be an open and doubtful question.

The crystalline limestones are particularly developed in the Ottawa River section from the vicinity of the Deschenes Lake, west of Ottawa city, to the village of Bryson. Here they form a tolerably continuous belt extending along the river for many miles, though their continuity is frequently broken by the presence of large areas of intrusive granitic and dioritic rocks. This portion of the section would, therefore, appear to represent the highest members of the Laurentian proper, and at one place, near the Chats, it is overlaid by a considerable breadth of Huronian-looking rocks, schists, etc., which have been described in earlier reports under the name of Hastings series. The crystalline limestone portion of the Laurentian has its most westerly outcrop on the river in the vicinity of the Coulonge Lake, a short distance west of the Black River, the rocks further westward being for the most part granitic gneiss, granite and syenite, to the mouth of the Mattawa. In that portion of the Ottawa River section east of Ottawa city the limestones occur rather as separate bands occupying generally synclinals in the upper stratified gneisses, which form in many cases well-defined anticlinals, and in certain sections of this area these anticlinals are repeated very frequently, presenting thus the aspect of a ridged structure, in which the inclination of the strata is generally at a high angle.

The rocks exposed along the route of the Mattawa and French rivers to Lake Huron are chiefly what have been regarded as Laurentian gneisses. There is, however, a general absence of crystalline limestones, which forms such an abundant constituent of the Laurentian further east; and this, as well as the apparent inferior position of the gneisses themselves, caused them at an early date to be placed at the very base of the geological series, thus constituting the Lower Laurentian of Logan and other early Canadian geologists.

Crystalline limestone is only very sparingly present in association with these gneissic rocks of the Mattawa section, and wherever noticed the evidence all seemed to point to the fact that it had been "caught up" by the gneiss during the irruption of the latter. On the south shore of Talon Lake, as well as in the southern channel of the falls at the outlet of this lake, a crystalline limestone was noticed in conjunction with a very massive red foliated granite. Although in many places the bedding of this limestone corresponds with the planes of foliation of the inclosing rock, still at one place on the north bank of the river, a short distance above the falls, the limestone is seen to be in unconformable juxtaposition, the bedding of limestone abutting against the foliation of the granite. The line of junction is irregular

and jagged. and the granite itself shows a much finer texture near the line of contact. The limestone contains a good deal of serpentine in small spots and patches, and would form excellent building stone as well as good material for burning for lime.

Crystalline limestone was also noticed on the east shore of the Great Manitou or Newman Island, in the eastern part of Lake Nipissing,as well as on two of the smaller islands composing this group. The limestone occurs associated with a massive red gneissic rock composed chiefly of a deep red felspar and a dark green chloritic material, the arrangement of the latter in approximately parallel bands and streaks, giving it a rather distinct foliation. The limestone is generally of a beautiful pink colour, and exhibits abundant small scales and crystals of biotite or fibrous radiating crystallizations of a dark green hornblende. It occurs in rather small quantities, and, like the Talon Lake limestone, seems to have become incorporated in the gneiss during its irruption. On Iron Island, in Lake Nipissing, small patches of a dark colored crystalline rock, containing a large proportion of calcite, has been sometimes described as a crystalline limestone, but an examination under the microscope reveals its irruptive character, the large quantity of calcite present resulting from the decomposition of the plagioclase originally present.

It is not possible here to go into the various theories in regard to these ancient crystalline rocks, but it may be well to mention certain facts in this connection. It may be safely stated that the old belief that the whole of these gneissic rocks represent ordinary aqueous sediments which have undergone such extreme metamorphism as to mask their original character, is now entertained by few geologists. The "basement complex," as it has frequently been called, has been shown to be composed of a great variety of rock types whose sole resemblance consists in the more or less parallel disposition of their component minerals. The excellent work of Professor Lehmann on the gneisses of Saxony gave a fresh stimulus to the study of these old rocks, and the rapid advances lately made in the science of petrography have caused geologists to take a fresh interest in them.

The work of Dr. A. C. Lawson for the Geological Survey of Canada in the Lake of the Woods and Rainy Lake districts, already referred to, accompanied by an extensive microscopical examination of the rocks of these districts, as well as the detailed petrographical studies of the late Prof. G. H. Williams in the Menominee and Marquette region of Michigan, defined clearly the fact that the foliation or lamination of these crystalline rocks does not necessarily imply an original bedded character, but in most instances has been the result of the enormous

mechanical stresses to which these rock masses have been subjected. The studies of both these observers in the field, as well as in the laboratory, led them to the belief that many of the crystalline rocks, which had formerly been regarded as altered sedimentary strata, were in reality of eruptive origin, and distinctly referable to the more commonly massive plutonic rocks.

The foliation noticed in these gneisses is produced either by (1) the alternation of light and dark bands, or (2) by the more or less parallel distribution of the component minerals. In many of the plutonic or deep-seated rocks, particularly the granites and similar allied types, a marked tendency is noticed in the bisilicates to aggregate themselves in certain spots or patches, leaving the rest of the rock mass comparatively free from these constituents. The dark spots (*Ausscheidungen*) so conspicuous in many granites are perhaps the most familiar examples of this "magmatic differentiation," as it has been called. A microscopical examination of these "spots" shows that they possess the same mineral constituents as the surrounding rock, and differ only in the relatively greater abundance of the bisilicates present—indeed felspar and quartz are only sparingly represented, if at all. As the basic constituents are the first to cool and to assume a crystalline condition, these segregations mark the first formed nuclei in the slowly cooling magma. The result of pressure on a rock, characterized by the presence of these masses would result in their being squeezed or drawn out into more or less lenticular areas, assuming an approximately parallel position to one another in a direction at right angles to the pressure.

Again, many of the dark bands present in these gneisses are seen to have have had their origin as dykes which have been intruded in a direction corresponding to the foliation, as offering the least resistance. The origin of many of these dykes of hornblendic schist may very often be clearly made out in the field, as they can be frequently traced along their strike into areas or residual cores of the unaltered massive diorites or diabases which for some reason have escaped the pressure or deformation to which the surrounding rocks have been subjected. In the case of the more massive of these gneisses where the foliation is produced by the approximately parallel position of the mineral constituents, their field relations, as well as their microscopical characters and chemical composition, reveal their true nature as eruptive granites which acquired a foliation as a result of pressure. In fact at the present time petrographers have abandoned the use of the term "gneiss" as applicable to any definite type of rock, and are inclined to make use of it in

a structural sense only or as a term of convenience when nothing very positive is known in regard to the constituents of the rock.

It has been conceded that many of the plutonic rocks, such as granite, diorite, etc., may, and, in fact, often do exhibit a tendency to a more or less parallel disposition of their component minerals so that it has now become customary where a rock has been subjected to examination, to speak of it as a gabbro-gneiss, diorite-gneiss, etc., in this way at once indicating the composition and texture of the rock mass.

Recent work in Archaean geology has likewise shown that a great deal of this gneiss has not only had an irruptive origin but was in a molten or a plastic condition at a time subsequent to the hardening of certain distinctly clastic rocks with which it came in contact. At what depth below the surface these rocks must have solidified to produce their perfect crystalline condition is a matter of conjecture. Moreover, no certain evidence has been produced of the existence of any surface volcanic rock with which they might most reasonably have been expected to be associated, although subsequent denudation and erosion may have removed all traces of such mantle or covering. Although in many instances this first formed floor has been shown by its contact with the Huronian clastics to have been in a very unstable condition, still in a great many cases its present attitude with regard to the overlying clastics may, and doubtless has been, maintained since its original formation. In the country immediately adjoining the Mattawa River, and in the eastern part of Lake Nipissing, the gneiss is usually very distinctly foliated, although in many cases large areas are characterized by the presence of the more massive and granitoid varieties, in which cases the foliation is often more or less obscure and occasionally absent altogether. The dip is generally to the south at a high angle; but near the outlet of the French River from Lake Nipissing, and for a considerable distance down the river, the gneiss is either horizontal or inclined at a very low angle to the south. As Lake Huron is approached, however, the gneiss is again tilted up, and displays a remarkably uniform dip in a southeasterly direction at a comparatively high angle. On a map shortly to be issued by the Geological Survey) as well as on some others previously issued) the attempt has been made to correlate the many conflicting strikes obtained through this district, and to show by means of certain lines the curious curving and twisting affected by this gneiss.

A large number of dykes cut these gneisses, but no petrographical examination has yet been made of their contents. A rather remark-

able and unusual dyke, about ten feet wide, was noticed cutting across the strike of the foliation of the gneiss on the most southerly of the Manitou Islands. The rocks comprising the dyke resemble in a striking manner the alnoite rock described by Dr. F. D. Adams as occurring at St. Anne's, on the Island of Montreal. Dykes of fine-grained felsite and veins of pegmatite are, as usual, tolerably abundant.

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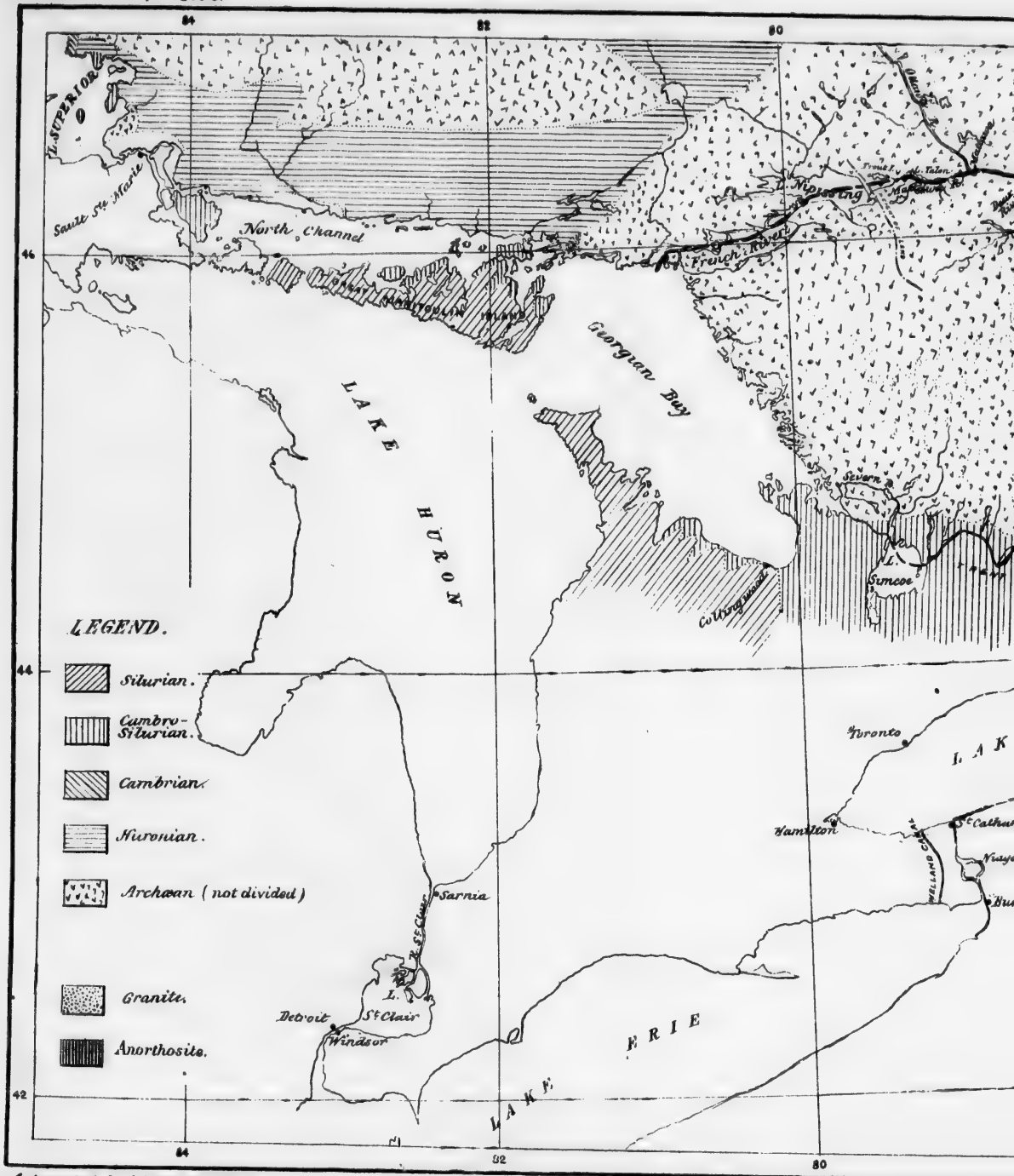

Autographed by C.O. Senecal, Ottawa.


MAP
Shewing the route
of the
PROPOSED OTTAWA CANAL
From
MONTREAL TO GEORGIAN BAY
To illustrate paper by
Dr. R W ELLS and A E BARLOW M.A.
Proposed Ottawa Canal:
Scale of Statute Miles.
10 5 0 10 20 30 40 50 60 70 80 90 100
LAKE ONTARIO
Toronto
Hamilton
St Catharines
Niagara Falls
Buffalo
WELLAND CANAL
Kingston
Thousand Is.
Belleville
Simcoe
Severn R.
Pembroke
Bryson
Portage du Fort
Ottawa
Hull
Montreal
Black R.
Coulonge R.
Bonnechere R.
Madawaska R.
RIDEAU CANAL
OTTAWA RIVER
ST LAWRENCE RIVER
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The following levels are based on a list published in 1860 by Thos C. Clarke, C.E., in a report on the Surveys of the Ottawa Ship Canal, addressed to the Hon. Commissioner of Public Works. His starting point, Lake St. Louis, is assumed as 57 feet above the sea, whereas the latest levelling of the Public Works Department gives it as 72·47 feet, that is 15·47 feet higher. This correction, after deducting 1·10 feet from Clarke's estimate of the rise between Ottawa and Grenville, would give an elevation of 588·37 feet for Lake Huron, as compared with 581·28 feet, the latest determination of the U.S. Coast Survey or 7·09 feet too high. This difference has been spread proportionately over the total rise and fall between St. Anne and the mouth of the French River. As a proof of the general accuracy of the levels thus deduced, it may be mentioned that the elevation given herein for Lake Nipissing is the same as that given by the corrected levels of the Northern Pacific Junction Railway (now part of the Grand Trunk Railway), and the elevation of the mouth of the Mattawa River also agrees with that deduced from the profiles of the Canadian Pacific Railway.

J. WHITE.

Miles from Montreal.	MONTREAL TO MATTAWA.	Rise—Low Water Section	Elevation above Mean Tide at Quebec, Low Water.	Elevation above Mean Tide at Quebec, High Water.	Difference between High and Low Water.
	Montreal Harbour—opposite Longueuil	.....	25·45	40·62	15·17
	" " " Round Island	.....	25·45	41·20	15·75
	" " at Victoria Bridge	8·55	34·00	42 00	8·00
	Lake St. Louis.....	38·47	72·47	80.36	7·90
22·00	Lower Ste. Anne.....	.....	72·47	79.0	6·50
22.10	Upper Ste. Anne..	1·00	73·5	82·5	9·00
47·70	Carillon Rapids..	1·00	74·5	86 5	12·00
49·00	Above Carillon Rapids.....	8·65	83·15	93·1	10·00
53·00	Chute a Blondeau Rapids.....	·05	83·2	95·2	12·00
53·10	Above Chute a Blondeau Rapids.....	3·95	87·15	102·35	15·20
54·50	Foot of Long Sault Rapids	·10	87·25	103·65	16·40
60·43	Grenville.....	45·30	132·55	147·35	14·80
116·50	Ottawa Harbour {Rise estimated at 1·20 ft.}	1·20	133·75	153·75	20·00
	Above Chaudiere Falls.....	41.85	175·6	183·6	8·00
118·50	Above Little Chaudiere Falls.....	8·00	183.6	190.6	7·00

Miles from Montreal.		Montreal to Mattawa.	Rise—Low Water Section.	Elevation Above Mean Tide at Quebec, Low Water.	Elevation above Mean Tide at Quebec, High Water.	Difference between High and Low Water.
		Above Remoux Rapids	2·80	186.4	194·4	8.00
122·86		Deschenes Lake	9·70	196·1	204·1	8·00
149·55		Foot of Chats Falls	30	196·4	206·4	10·00
150·05		Above Chats	37·60	234·0	238·0	4·00
153·16		Chats Lake	11·70	245·7	252·7	7·00
171·13		Foot of Cnenaux Rapids	·20	245·9	252·9	7·00
171·33		Head of Chenaux Rapids	·60	246·5	256·5	10·00
175·73	Calumet Channel	Portage du Fort Rapid	1·80	248·3	258·3	10·00
		Head of Portage du Fort Rapid	12·90	261·2	270·2	9·00
181·33		Mountain Rapid	6·10	267·3	277·3	10·00
		Head of Mountain Rapid	13·20	280·5	293·5	13·00
		Head of Dargies Rapid	1·70	282·2	.....	.....
		Foot of Calumet	5·60	287·8	297.8	10·00
184·14		Head of Calumet	55·10	342·9	351 9	9·00
202 20		La Passe	4·20	347·1	357·1	10·00
175·73	Roche Fendue Channel	Portage du Fort Rapid	.....	261·2	270·2	9·00
183·00		Roche Fendu Falls	·50	261·7	271·7	10·00
184·50		Long Rapids	6·30	268·0	277·0	9·00
186·00		La Barriere	16·20	284·2	296·2	12·00
187·00		Muskrat Rapid	3·20	287·4	296·4	9·00
188·00		Mice Rapid	6 80	294·2	303·2	9·00
188·50		La Fontaine's Lake	3·20	297·4	305·4	8·00
189·50		Black Rapids	18·50	315·9	325·9	10 00
190·30		Black Falls	17·65	333·55	343·55	10·00
192·00		Flat Rapids	11·85	345·4	355·4	10·00
195·92		La Passe	1·70	347·1	357·1	10·00
206·60		Foot of Allumette Island	2·55	349·65	360·65	11·00
215·43		Foot of Chapeau Rapids	·75	350·4	361·4	11·00
215·50		Head of Chapeau Rapids	·60	351·0	362·0	11·00
220·35		Foot of l'Islet Rapids	·60	351·6	362·1	10·50

Miles from Montreal.	MONTREAL TO MATTAWA.	Rise—Low Water Section.	Elevation above Mean Tide at Quebec, Low Water.	Elevation above Mean Tide at Quebec, High Water.	Difference between High and Low Water.
221·10	Head of Culbute Rapids	16·90	368·5	375 5	7·00
226·40	Fort William	·30	368·8	375·5	6·70
254·00	Head of Deep River	1·30	370·1	379·9	9·80
255·64	Head of Des Joachims Rapids	26·10	396·2	413·2	17·00
263·30	Mouth of Dumoine River	1·00	397·2	414·9	17·70
268·25	Foot of McSorley's Rapids	3·00	400·2	.....	.....
269·00	Head of " "	2·90	403.1	.....	.....
272·50	Foot of Rocher Captaine Rapids	2.90	406.0	.....	.....
273·85	Head of " " "	40·45	446.45	460·45	14·00
285 55	Foot of Deux Rivieres Rapids	4·25	450·7	466·3	15·60
286·01	Head of " " "	12·50	463·2	.....	.....
286·70	Foot of Trou Rapids	·80	464·0	.....	.....
287·15	Head of " " (at Micmacs)	7·30	471·3	488·7	17·40
288·10	Foot of L'Eveille Rapids	2·80	474·1	.....	.....
288·70	Head of " "	7·40	481·5	.....	.....
296·75	Foot of Rocky Farm Rapids	·40	481·9	.....	.....
301·50	Head of " "	8·40	490·3	.....	.....
306·55	Foot of Johnson's Rapids	·80	491·1	.....	.....
307·00	Head of " "	4·80	495·9	.....	.....
307·60	Foot of Mattawa Rapids	·10	496.0	.....	.....
308·00	Head of " "	2·90	498.9	513·2	14·30
308·00	Mouth of Mattawa River	.....	498·9	.....	.....
	MATTAWA AND FRENCH RIVERS.				
308·00	Mouth of Mattawa River	.....	498.9	.....	.....
310·40	Foot of Plein Chant Rapid and Chute	5·40	504·3	.....	.....
310·80	Foot of Lac Plein Chant	16·70	521·0	.....	.....
316·25	Foot of Des Epines Rapids	·20	521·2	.....	.....
316·30	Head of " "	5·50	526·7	.....	.....
316·85	Foot of Rapide de la Rose	·20	526·9	.....	.....

Miles from Montreal.	Mattawa and French Rivers.	Rise—Low Water Section.	Elevation above Mean Tide at Quebec, Low Water.	Elevation above Mean Tide at Quebec, High Water.	Difference between High and Low Water.
317·00	Head of Rapide de la Rose	5·55	532·45	.....	.....
318·20	Foot of Rapide des Rochers	1·35	533·8	.....	.....
318·30	Head of " "	4·80	538·6	.....	.....
319·00	Foot of Rapides des Aiguilles	·10	538·7	.....	.....
319·01	Head of " "	·40	539·1	.....	.....
321·65	Foot of Chute des Paresseux	.....	539·1	.....	.....
321·85	Head of " "	33·40	572·5	.....	.....
322·20	Foot of Little Paresseux Rapids	.....	572·5	.....	.....
322·35	Head of " " "	8·10	580.6	.....	.....
323·38	Foot of Lake Pimisi (Eel Lake)	12·70	593·3	.....	.....
324·53	Foot of Talon Chute	.....	593·3	.....	.....
324·71	Head of " "	42·30	635·6	.....	.....
325·18	Rapid below Lake Talon	.....	635·6	.....	.....
325·33	Foot of Lake Talon	·90	636·5	641·6	5·10
332·34	Head of " "	.....	636·5	.....	.....
336·08	Foot of Turtle Lake	29·55	666 05	667·85	1·80
339·36	Foot of Trout Lake	·90	666·95	.....	.....
347·79	Head of " " (summit level)	.....	666·95	669·75	2·80
	Proposed summit level of canal to be obtained by lowering Trout and Turtle Lakes and raising Lake Nipissing..... 659·1 ft.				
351·98	Lake Nipissing, east shore	Fall. 24·75	642·2	.....	.....
382·42	Head of Chaudiere Portage	.....	642·2	649·5	7·30
382·72	Foot of " "	25·60	616·6	.....	.....
384·63	Foot of Chaudiere Rapids	·70	615 9	619·6	3·70
391·60	Head of Rapide du Pin	.....	615·9	619·2	3·30
391·69	Foot of " "	2·60	613·3	.....	.....
392·45	Head of Grande Faucille Rapid	10	613·2	616·6	3·40
392·53	Foot of " " "	5·70	607·5	.....	.....
393·22	Head of Rapide du Buisson	·40	607·1	.....	.....
393·32	Foot of " "	3·30	603·8	.....	.....

Miles from Montreal.	Mattawa and French Rivers.	Rise—Low Water Section.	Elevation above Mean Tide at Quebec, Low Water.	Elevation above Mean Tide at Quebec, High Water.	Difference between High and Low Water.
393·78	Head of Petite Faucille Rapid	.....	603·8	.....	.....
394·00	Foot of " " "	4·40	599·4	605·8	6·40
395·49	Head of Rapide du Parisien	·80	598·6	.....	.....
395·70	Foot of " "	1·20	597·4	601·2	3·80
412·72	Head of Grand Recollet Rapids	·30	597·1	.....	.....
412·74	Foot of " " "	6·90	590·2	.....	.....
413·74	Head of small rapid	·10	590 1	.....	.....
413·82	Foot of " "	·70	589·4	.....	.....
417·54	Head of small rapid	.....	589·4	.....	.....
417·64	Foot of " "	2·00	587·4	591·3	3·90
427·81	Head of Petites Dalles Rapid	.....	587·4	.....	.....
428·02	Foot of " " "	6·10	581·3	.....	.....
430.76	Mouth of French River	.....	581·3	.....	.....